MECHANICAL AND THERMAL PERFORMANCE OF PHASE CHANGE MATERIAL INTEGRATED CONCRETE WALL PANEL

SHORT SYNOPSIS

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CERTIFICATE

I hereby declare that the short synopsis "Mechanical and Thermal Performance of Phase Change Material Integrated Concrete Wall Panel" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Department of Civil Engineering under the School of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2024. It is a bonafide record of original work carried out under the supervision of Dr. Senthil Vadivel T, Professor & Head, Department of Civil Engineering, and has not been submitted in full or part to any other University or Institute for Degree or Diploma. Further, it is certified that the short synopsis is plagiarism-free and the proof has been submitted.

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ABSTRACT

Incorporating Phase Change Material (PCM) into buildings for thermal energy management, it is possible to significantly enhance energy efficiency. Thermal energy management approaches based on environmentally assisting construction materials is considered as one of feasible systems. PCMs have the privilege to save energy by latent heat and to take up less volume than other thermal storage construction materials. Phase Change Materials may be used into the building envelope through several methods. One of the most streamlined approaches of incorporating PCM is directly into the construction materials. This technique reduces the cooling demand while enhancing the internal thermal nature of the structures. Significant study has been conducted on the potential use of PCMs in concrete and other building materials. The findings showed that PCM incorporated materials has various beneficial properties, including excellent thermal performance and latent heat storage. This research aims to explore the integration and influence of Phase Change Materials (PCMs) on the properties of concrete in wall panels. The methods for improving the thermal conductivity of concrete wall panel, consists added additives directly and encapsulating of phase change materials. An experimental evaluation is going to be conducted to assess the impact of phase change materials (PCMs) on the mechanical strength qualities, thermal performance, and thermal conductivity of concrete wall panels integrated with PCMs. Lastly, find the possible applications of PCMs integrated concrete wall panel in construction materials how to be leads to the increase of thermal storage capacity of building envelope and it contributes ultimately to keeping thermal comfort inside buildings.

Keywords: Building wall panel, Concrete, Energy Efficiency, Phase change material (PCM), Sustainable Buildings, Thermal Comfort, Thermal Energy Storage

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1. INTRODUCTION

1.1. Energy Efficient Buildings

The global building sector has experienced a rise in energy consumption in recent decades. In order to balance the energy demand in the construction industry, an effective and cost-effective method must be implemented. Researchers are diligently working on energy conservation in response to the increasing demand for energy in future buildings. Among the several utilities that use energy in buildings, HVAC (heating, ventilation, and air conditioning) systems account for a significant amount of energy usage. These systems are responsible for creating comfortable areas for occupants by controlling and keeping the air temperature at a consistent level. Utilizing phase change materials (PCMs) for Latent Heat Thermal Energy Storage (LHTES) in buildings is the optimal choice for mitigating temperature fluctuations and achieving energy efficiency (Xing Jin, 2014). Methods for reducing temperature and promoting heat dissipation without the use of active cooling systems. Implementing phase change materials in buildings is a cutting-edge innovation for thermal management. It improves the comfort conditions by regulating air temperature and reduces the peak energy demand on HVAC systems. Buildings that are fitted with Phase Change Materials (PCMs) store the maximum amount of solar energy available during the day, minimise the amount of heat gained from the external environment, and release this stored energy at night to provide thermal comfort. This is possible because the presence of PCMs lowers the temperature at which they change from solid to liquid. Therefore, Phase Change Materials (PCMs) are seen as promising options for regulating temperature in buildings (A M Khudair, 2007).

Phase Change Materials (PCMs) have the ability to undergo phase transitions within a narrow range. They may be effectively utilized in buildings as Low-temperature Heat Storage (LHTES) materials, provided that there are small temperature changes required. Traditional building materials function as effective heat and thermal energy conservation systems that collect, retain, and emit solar energy both during daylight hours and at night (A Pasupathy, 2008). Research was attracted to the use of Phase Change Materials (PCMs) in building envelopes for temperature control. This was because PCMs are able to reduce heat flow by storing heat energy at a specific temperature until they melt, thereby acting as a thermal mass

insulator to prevent exterior heat gain. Subsequently, the phase change material (PCM) emits thermal energy when the surrounding temperature falls below the PCM's point of solidification (Zhang, 2007).

1.2. Phase Change Materials

Phase-changing materials (PCMs) are substances that transition from one phase to another without appreciably changing temperature. The two most common types of phase transitions are solid-to-liquid cycles, which alternate. Given the complexity of other phase transitions and the need for a significant quantity of energy to be stored and released, studies on the solid-liquid-solid transition inside phase change materials (PCM) have been particularly fascinating. The process of melting occurs by the absorption of heat from the surrounding environment, leading to an endothermic mechanism. After a period of solidification, heat is released to the surroundings, resulting in an exothermic process. In addition to releasing and conserving energy, PCMs have two primary benefits: (i) sufficient heat absorption with little temperature variation; (ii) stabilisation of temperature imbalance leading to isothermal phase transition behaviour (Arivazhagan R, 2020). When the ambient temperature exceeds the PCM melting point, phase change materials (PCMs) incorporated into buildings change their phase, therefore storing heat energy that is released at night. While phase change occurs at a constant temperature, the rise in abeyance building heat over a specific period leads to a change in the peak energy demand for HVAC systems. This, in turn, reduces energy consumption and air temperature fluctuations in buildings. Thermal management in buildings can be effectively achieved by deploying phase change materials (PCM) to address the transient temperature fluctuations across day and night cycles (Sarı, 2016). Although vaporisation has a higher latent heat than fusion, it is rarely employed in industry due to its tendency to increase system pressure and require a significantly large specific volume. Physical, chemical, thermodynamic, kinetic, and economic characteristics are among the important aspects that influence the selection of a phase change material (PCM) (Harikrishnan S, 2019). The fusion temperature of phase change materials (PCMs) implemented in buildings is crucial in the selection of PCMs for thermal energy management. This is because the latent heat of PCMs can only be fully utilised if there is complete melting and solidification. Furthermore,

phase change materials (PCMs) with a low transition temperature were favoured for the management of thermal energy in buildings (Hawes D.W, 2009). Save energy through latent heat, sensible heat, and chemical processes. The huge energy storage ability of phase-change materials (PCMs) in latent heat-absorbing techniques makes them compactable. Therefore PCMs could apply building interior space heat efficiency (Elnajjar, 2017).

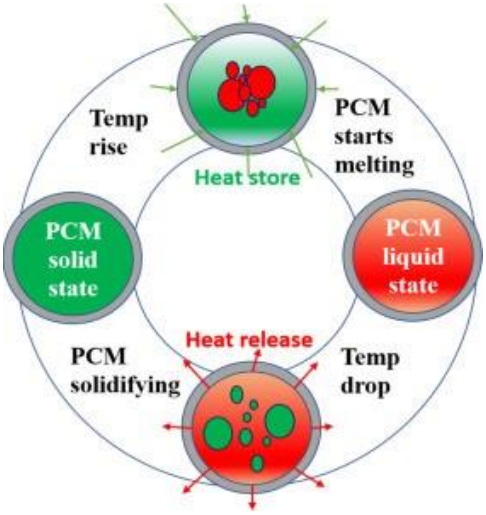

Figure 1: *Function of PCMs* (Samykano, 2022)

The energy should be conserved through either latent heat, perceptible heat, or chemical processes. Phase-change materials (PCMs) are compactable mostly due to their significant capacity for storing energy in latent heat-absorbing processes. Therefore, phase change materials (PCMs) were able to enhance the thermal efficiency of interior spaces in buildings. (Borreguero A.M, 2014). As a thermal absorption unit, use G/C gypsum cement envelope wall boards. These boards contain a possible quantity of PCMs. Because of this, structures should be ventilated using energy-efficient gypsum cement materials. (Chen.C, 2008). Thermal energy can absorb energy from warm air in the atmosphere during the hot weather season. It can release stored energy, because the lower air temperature at night lowers PCM's melting point. Contrary to PCMs, organic PCMs such as paraffin and fatty acids are favoured as common potential ingredients due to their strong latent heat management capacity, reduced vapour persistence during melting, safety, chemical state, and affordability (Zhang Z, 2013).

In this study is to explore the potential of paraffin wax and gypsum powder as modifying materials for the construction of envelopes at various heat conditions. The major objective of

this work is to produce heat-absorbing PCMs using gypsum-integrated concrete wall panels and analyse their physical characteristics and thermal energy results in hot weather conditions (Peiwen, 2015). This research, however, focusses on the efficiency of heat transfer and confirms its robust properties. Direct mixing and enclosed mixing procedures are likely to be used to build heat-absorbing PCM with Gypsum embedded concrete wall panels. In order to accomplish this, two distinct wall panels, one for enclosed mixing walls and another for PCM direct mixing walls, are in the works. The development of PCMs with gypsum-integrated concrete wall panels will involve the use of organic PCMs containing paraffinic wax. Particularly, this work will examine the impact of the heat storage efficiency of PCM with gypsum-integrated concrete wall panes using dynamic heat transfer analysis from the experiment (Su-Gwang Jeong, 2019). PCM-concrete has been prepared by combining paraffin wax with a melting point of 58 °C and make as a heat storage block. PCM-CLSC aggregates mixed with concrete to ensure leakage prevention to prepare the thermal storage blocks (PCM-CTSB) (Yongliang Shen, 2021).

The thickness of the PCM added into the concrete wall is the important factor regarding strength and thermal properties valuation. Energy transferring ability also depends on its thickness (Jawed Mustafa, 2022). The thermal energy storage aggerate (TESA) utilized in concrete. TESA aggregates prepared by the help of salt-hydrate based PCM which improves the efficient energy properties (Hongzhi Cui, 2023).

The recycled aggregates were exercised as embrace for PCM, thereby furnishing to the enhancement of construction and demolition waste. PCM addition into the concrete by two methods, adding by form-stable procedure and direct mixing of PCM, both the methods are evaluated PCM added concrete's physical and thermal behaviors. PCM aggregates providing feasible insights for optimizing PCM concrete composite materials and also as energy controlling and durable building materials. Strength properties slightly depends upon the solid state of the concrete mixing method possibly direct mixing shows better the form-stable methods (Zhiyou Jia, 2024).

2. DESCRIPTION OF BROAD AREA

Building companies, especially those in metropolitan areas, are looking into and implementing new energy management strategies. Using phase change materials (PCMs) in exterior building design is one way to improve thermal energy management, which could lead to better thermal insulation and reduced energy expenditures. Because it is integrated into the building components, it reduces the peak demand for heat during the energy savings period. Countries are focusing on increasing their energy production rates because the amount of energy consumption per capita is influenced by a community's living standards and economic status. A key concern, though, is the accessibility of scarce resources and the environmental damage they do. Because of this, methods for improving energy efficiency and reducing energy consumption, particularly in the building area, without compromising the sustainable impression of building envelope materials must be identified.

In recent years, the use of PCMs in building elements like floors and walls has been critically assessed as an effective method for passive solar heat absorption advantages. Incorporating PCM into building elements such as walls, roofs, and floors can effectively mitigate thermal variations, particularly in situations when cooling radiation requirements are high. It was presumed that PCM based passive latent heat storage techniques could imparts to improve inside thermal comfort and reduce peak air temperature, decrease of day-to-day thermal energy oscillation, modifying in the air space temperature of structures. Integration of PCMs improves construction envelope materials efficiency and to develop material performance through insulation ability, changes in thermal move along them, magnifying the thermal energy. Also coated PCMs helps in control the cooling and heating peak demand, storing thermal energy consumption take benefits of sustainable resources like solar energy, save direct cost during the functional phase and provide the reduction of CO_2 discharges along with cooling and heating for buildings as well as environment.

Although, the characteristics likes chemical significance, fire resisting and similarity with conventional building materials and more attention needs in the PCMs preferences. PCMs shows a significant result on latent heat storage lowering the temperature modulation by absorbing thermal energy when day time to passive thermal have been utilize in walls, floors and ceilings and of buildings. Organic PCMs shown effective performance due to their significant latent heat capability, suitable phase changing temperature and secure physical and

chemical properties. During the phase change process of PCMs to prevent their leakage the techniques of encapsulation process need to covering PCM with shells while incorporating. Basic ventilation system must be arranged for managing heat discharged during the PCM solidification at night time interior space of building.

The incorporating PCM encapsulated instantly into the construction elements such as mortar, concrete, and bricks based the impacts of real hot and humid countries like India, the demand of thermal energy heating and cooling in residential and commercial structures is more concentrated. The experimental encapsulated PCM elements have performed at high load temperature deduction all alignments and inner air space temperature. Considering the possible benefits of PCM integration into the building materials somehow need to focus the difficulties facing while using these kinds of building materials. PCMs integrated alongside the construction materials the thermal energy observing potential additives improves and accordingly well with inside the internal thermal nature; Thereby, it is an appropriate method to reduce energy absorption in passive-mode structures. Thermal energy storage with PCM has attracted growing attention for its role in achieving energy conservation in buildings with thermal comfort. This susceptibility is inferred from the abundance of scientific articles in the literature.

The proposed study is an experimental evaluation of concrete wall panels that use phase change materials (PCM). The objective is to experimentally assess the mechanical strength, thermal conductivity, and thermal performance of PCM-based gypsum concrete wall panels using twin identical mixing procedures. Furthermore, it is intended to assess the effects of modifying the PCM/Gypsum mix matrices in order to determine the minimal PCM/Gypsum matrix needed to achieve the desired strength properties and the optimal thermal conductivity for use in PCM-based gypsum concrete wall panels in comparison to conventional concrete wall panels.

3. LITERATURE REVIEW

Using a computational enthalpy model, Guobing Zhou (2007) investigated the energy-efficient performance of composites including PCM in a Beijing passive solar building. The combined type PCM gypsum and model stabilised PCM plates optimally save the indoor temperature swap; the model stabilised phase change material (SSPCM) plates acknowledge quickly compared to the combined type PCM and gypsum, which is thermally wetter; and the PCM compound with small phase transition zone softens at 21°C.

Frederic Kuznik (2009) created a light building envelope in an experiment using PCM-filled walls to improve building thermal comfort. PCM in walls progressively reduces excessive heating, and radiated heat and room air are lost as the temperature declines. PCM wallboards reduce wall heat and increase indoor warmth through radioactive heat transfer. PCM material helps air convect, reducing temperature stratifications. PCM wallboard's porosity and durability density must be assessed to determine its potential as a lighter building envelope material.

The application of PCM-containing microcapsules to improve the thermal behaviour of gypsum blocks was investigated by Ana M. Borreguero in (2010). The paraffin wax Rubitherm RT27 and polystyrene shell are combined in a microcapsule PCM via a suspension-like polymerisation phenomenon facilitated by a holding stirrer. The highest thermoelectric energy storage capacity was achieved when the core coating mass ratio in the synthesis module was 1.5. As the mass ratio of paraffin wax to styrene monomer increases, the microencapsulation capability is reported to decrease. The use of PCM filled microcapsules enhanced the thermal insulating properties of gypsum. As the microcapsule particles within the wall undergo expansion, the localised heat distribution becomes more uniform, but the temperature of the wall remains relatively stable. By integrating 7.5% of microcapsules, which include PCMs, into the wall, it is possible to regulate the temperature of the region behind it at the highest or lowest setting by a maximum of 1.3 °C.

Tommaso Toppi (2013) investigated gypsum's experimental correlation measurements and utilized a composite material containing paraffin microcapsule particles. Commercial construction materials made from the same raw units but using various processes have consistent, straightforward, and exact assessment value relationships. As the starting combination becomes more liquid, gypsum and composite materials' density and thermal management links decrease. Impacts on microcapsule thermal properties are examined from two angles. Microcapsules have different properties than gypsum matrix, yet their presence promotes micro voids and changes their nature. The amount of microcapsules injected is a crucial factor in the nature of the changes in the properties of the gypsum. The discussions propose that the specific thermal capacity remains relatively constant due to the influence of liquid state contents on material porosity rather than chemical structure. The suitability of the correlations for observing the gypsum characteristics is not influenced by temperature. Correlations derived from the concept of material combination enable the identification of a composite including gypsum and its constituent components. This evidences satisfaction when the incorporation of materials undergoes modifications or must be capable of achieving thermal efficiency in building.

Rasoul Shadnia (2015) assessed the impact of the geopolymer mortar integrated PCMs' thermal and physical behaviours. Incorporating PCM into geopolymer mortar reduces its unit mass due to its lower unit weight. This reduces the geopolymer mortar wall and building weight, making them lighter. Compressive strength reduces when PCM is added to mortar. Despite the slight drop, geopolymer mortar with up to 20% PCM offers enough compressive strength for constructions. The SEM images clearly demonstrate the strong adhesion of the PCM to the adhesive. The incorporation of PCM improves the thermal efficiency of the geopolymer mortar, indicating that the PCM can potentially accelerate heat conduction. The application of geopolymer mortar, which incorporates PCM, as a building envelope can greatly enhance the thermal efficiency of structures and effectively manage the energy consumption associated with heating and cooling also control the inside thermal limit.

Using PUM/CA-PA, PUM/DD, and PUM/HEPD as examples of innovative FS-CPCMs, Ali Karaipekli (2016) examined their characteristics and capacity to absorb thermal energy. Utilising vacuum saturation, the FS-CPCMs were used. The results of the DSC analysis indicate that the suggested composite materials possess significant thermal absorption and release capabilities within the range of human thermal comfort (18–25 °C). This study developed PUM-based PCM composites for large-scale production, which reduces PCM impacts on the environment, direct addition without encapsulation, improved thermal shifting room area, appropriate phase change environment for construction benefits, and heavy thermal energy storage. Their production procedure is standard and cheaper. Experimentally researched composites are ensuring materials for thermally efficient building management, even though the compound plaster with PUM/HEPD showed greater energy efficiency because to its large latent heat stability and chemical stability. Whatever the case, their effects on mortar or concrete strength, durability, and inflammability should be assessed.

Thermophysical characteristics of wallboards with PCM integration were examined by Chaoen Li (2019). A hot plate apparatus measured thermal conductivity, ambient specific heat, and H(t) action improvements. MPCM-integrated wallboard has lower thermal conductivity and organic PCM efficiency than traditional gypsum wallboard because micro-PCM lowers gypsum density. At 26°C to 32°C, mixed PCMs wallboard has 2.71 times the specific heat capacity of gypsum wallboard. The corresponding approaches used the DSC data dynamic technique's theoretical computation and related step strategy to find H(t). The dynamic technique may require an appropriate temperature value for the application.

Su-Gwang Jeong (2019) evaluated the physical and thermal properties of PCMs made from n-octadecane and beeswax using a vacuum impregnation process. These PCMs might be used to make thermally absorbent cement or gypsum panels. The FTIR analysis revealed that the heat absorption G/C panels retained their distinct chemical properties of PCMs. The thermal absorption G/C panels achieved a 130% and 150% enhancement in heat efficiency based on its basic PCMs. DSC measured latent heat abilities of 48.03 and 34.08 J/g when heating and 45.45 and 30.54 J/g while freezing for n-octadecane integrated and beeswax combined gypsum panels. The n-octadecane-based G/C panels had 82.15 J/g final physical observations at 80 degrees Celsius, whereas the beeswax-based panels had 87.57 J/g. Beeswax-based G/C boards outperformed n-octadecane-based panels in thermal efficiency tests.

The simulation research of energy conservation in buildings found that PCM with a G/C board improves building energy efficiency. G/C boards with n-octadecane reduce energy consumption more. This study examined heat-absorbing G/C boards for use as interior envelope building materials, ceiling panels, and wall boards. It must be pre-confirmed before being fitted to the area that needs porosity if it is built by integrating PCM on the present G/C board.

Pushpendra Kumar (2019) described that macro-encapsulated PCM could absorb heat in building. The utilisation of PCMs in energy absorption activities can significantly contribute to the maintenance of indoor room temperature by relocating peak demand to off-peak energy demand periods and reducing energy demand for cooling and heating. By encapsulating the PCMs and incorporating it into the construction materials, it will not only achieve the stated objectives but also be safeguarded from loss and seepage. In comparison to the components used for sensible high-temperature absorption, the capacity of PCM to absorb latent heat may lead to thermal energy savings that are 5.01–14.00 times higher. These PCMs components preserve the structural integrity while enhancing the heat transfer mass over the PCM interface. Minimising the size of the PCMs and increasing the proportion of macro-encapsulated PCM used in the building component result in reduced cooling energy consumption. Further reduction in cooling energy needs can be achieved by enlarging the dimensions of the enclosed PCMs. The incorporation of macro-encapsulated PCM into construction materials can effectively reduce elevated temperatures and heat oscillations in the interior space, therefore enhancing thermal comfort within the building. To achieve the best possible thermal control of the enclosed PCM, it is recommended to install adequate ventilation in the building. Implementing MPCM in building supplies is likely to result in a more favourable delay value. In due course, the cost-effectiveness of heating and cooling will diminish, and the level of energy efficiency will enhance.

Arivazhagan R (2020) suggested examining concrete blocks experimentally, both with and without PCM, to assess their thermal performance. Incorporating PCM into cement concrete blocks reduces the air temperature variation by 3°C compared to concrete blocks without PCM. Additionally, the heat-absorbing properties of PCM result in a flattening of the air temperature inside the PCM during the phase transition from solid to liquid. Therefore, PCM

was considered important for enhancing the thermal efficiency of buildings by reducing energy consumption from HVAC systems and providing thermal comfort to occupants.

Rafid Jahangir khan (2020) The inclusion of PCM in building walls results in the lowest temperature gain compared to other building materials, as PCM effectively delays the time needed to reach a certain temperature and efficiently absorbs heat without greatly impacting the temperature inside the building space.

Yongliang Shen (2021) evaluated thermal study of PCM-concrete thermal storage block (PCM-CTSB), PCM-concrete was created by blending paraffin wax with CLSC aggregates, which were then incorporated into the concrete mixture to prevent any leaks. Based on the evaluation, the PCM-CLSC aggregate formed a structured modular system with the paraffin evenly distributed throughout, making CLSC a reliable choice as the PCM matrix.

Jawed Mustafa (2022) discussed the effect of PCM on concrete walls, the thickness of the concrete wall is considered to 100 mm and the thickness of the PCM added concrete wall reaches 130 mm, utilizing for energy transfer, the high thermal conductivity of concrete results in increased energy transfer with in PCM walls.

Hongzhi Cui (2023) described thermal-mechanical behaviors of concrete with salt hydrate PCM-based aggregate (TESA) with a core shell structure, and it is proved to be adequate encapsulation. Also, the prepared TESA reveals desirable properties such as good latent heat, suitable phase change temperature, thermal stability, lower supercooling, no segregation, and desirable chemical.

Zhiyou Jia (2024) suggested the integration of PCM within concrete adopting methods of form-stable PCM and direct mixing, the viability of employing both PCM application methods in concrete was analyzed, PCM providing feasible insights for optimizing PCM concrete composite materials as energy-efficient and durable building materials.

3.1. Research Gaps

Experimental research on thermal energy management applications in buildings have shown that phase change materials (PCMs) are vital role in the development of building envelope materials for energy efficiency. These research state that the strength properties, thermal performance, numerical studies, and correlation between different composites are experimentally explored for PCMs integrated with gypsum-based mortar, wall boards, and concrete blocks. However, the gaps indicated by the researcher need to be understood to identify the key points and develop further solutions for them.

1. PCM thickness impacts thermal management, causing incomplete liquefying, solidification, and energy storage. If block dimensions change, the optimal PCM thickness must be determined, which is based on the construction material's strength and thermal properties.
2. To determine whether kind of mixing produces a better finished product for constructing envelopes, direct mixing and encapsulation mixing must be compared.
3. PCM mortar with up to 20% PCM inclusion is strong and ideal for building uses, with negligible compromise in strength quality. Based on this which needs to identify the best mix proportions for PCM-based concrete or mortar to obtain its strength used as a building material.
4. Organic PCM/gypsum composites offer a cost-effective solution due to their straightforward formation process and lower expenses. The integrated composite PCMs show promise for efficiently storing thermal energy in energy-efficient construction. However, additional evaluations are needed to determine their potential for direct use with concrete or mortar in terms of physical strength and thermal performance.

4. OBJECTIVES OF THE STUDY

1. To create PCM integrated concrete wall panels using manual method
2. To assess the mechanical strength performance of PCM integrated concrete wall panels mixed in different proportions both directly and encapsulated, as well as plain cement concrete wall panels (PCCWP).
3. To compare the thermal conductivity of ordinary cement concrete with the selected mix proportional to PCM-integrated concrete samples
4. To assess the variation in heat flow and temperature values of gypsum-based PCM aggregates through the Differential Scanning Calorimetry test, in order to determine their specific heat capacity
5. To evaluate the thermal performance of plain cement concrete wall panels (PCCWP) and PCM-integrated concrete wall panels to determine their thermal energy management over PCCWP for energy storage applications.

5. PROPOSED METHODOLOGY

Phase change material (PCM) integrated concrete wall panels will be developed by manual method following a comprehensive literature review. To create PCM-integrated concrete wall panel specimens with varying PCM composite content. Three types of mixing procedures will be implemented: Initially, Portland Pozzolana Cement (PPC) and sand are mixed together for 5 minutes using a mixer machine to ensure uniformity of the dry mortar. Subsequently, coarse aggregate is added to the mortar and thoroughly mixed for 5 minutes. Finally, prepared PCM-gypsum composites are added to the dry concrete mortar and thoroughly mixed for further 3 minutes. PCM aggregates added at the end of mixing reduce PCM damage. The next step is to add the water to the dry concrete mixture and stir until thoroughly combined to improve workability, the molds were filled with fresh concrete and do proper compaction to eliminate any trapped air bubbles. Subsequently, the panels were positioned for standard curing following a 24-hour period. It is necessary to take into account the ambient temperature of around 23^{o}C. PCM aggregates are using to replace an equal proportion of

coarse and fine aggregates. The quantity of PCM aggregates is then calculated by considering the unit weight ratio. The shapes of the suggested PCM integrated concrete wall panel are regarded to be about rectangular cubic forms. Rectangular shape the wooden form into a casting mold with the following dimensions: 300 mm x 300 mm x 90 mm.

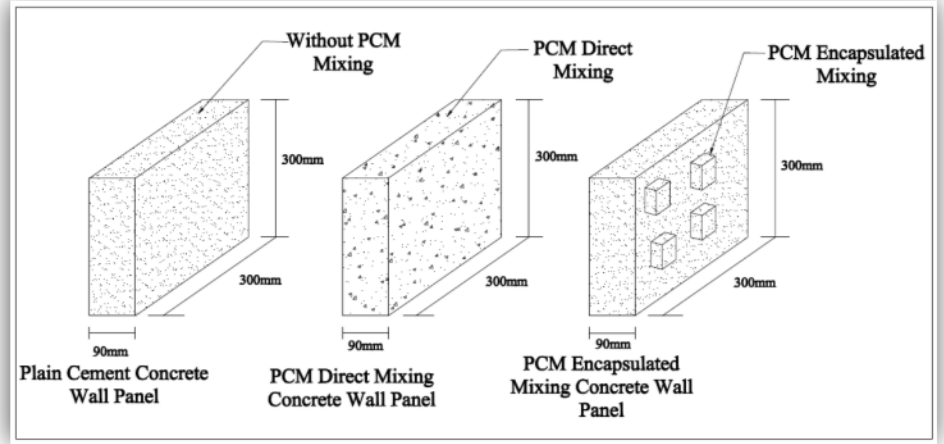

Figure 2. *Model Casting image of PCM Integrated Concrete Wall Panel*

Uniaxial compression strength (UCS) tests will be performed to determine the impact of using phase change material (PCM) aggregates on concrete panels. The UCS tests going to be conduct on concrete wall panels incorporating PCM at 0%, 5%, 10%, 15%, 20%, and 25% concentrations after 7, 14, and 28 days of complete curing. Three specimens considering both encapsulated and direct mixing of PCM at each %. Results will be derived by averaging the values obtained from three specimens. Each panel's every surface was rubbed until it was perfectly flat and parallel before the strength test. Based on the upcoming results, select the most favorable PCM-Gypsum mix ratio from both direct mixing and encapsulated mixing samples and compare it with that for strength of PCM concrete wall panel. Moreover, the PCM-Gypsum mix ratio is chosen based on its appropriate mechanical strength characteristics of panel also that sample PCM concrete panels will be consider for thermal performance.

For thermal performance tests to understand the comparison of PCM-integrated concrete wall panels in controlling thermal management. Regarding thermal performance test the small covered room space will be constructed by plain cement concrete panel and also PCM incorporated wall panel separately. In that small room space the East and West direction wall surface is consider for taking temperature value from both inner and outside of panel with top

middle and bottom points. The temperature value is going to be measured by the help of Infrared Thermometer in regular intervals up to three days after that based on the observations which panel provides better thermal energy efficiency will be evaluated. The Differential Scanning Calorimetry (DSC) test will be performed in order to determine their specific heat capacity of gypsum-based PCM aggregates and normal aggregates. Finally Thermal conductivity value based on ASTM-D3850 standard test will be evaluated for each concrete panel. The thermal conductivity of cement-combined PCM concrete is a common factor while consisting the quantity of heat managing through conduction. Thermal conductivity of any material is a measure of how heat moves through that material. Therefore, experimental investigations are required in order to understand the mechanical and thermal performance of PCM-integrated concrete wall panels. In this study, the PCM-integrated experimental performance approach will be applied to develop energy saving sustainable building construction materials.

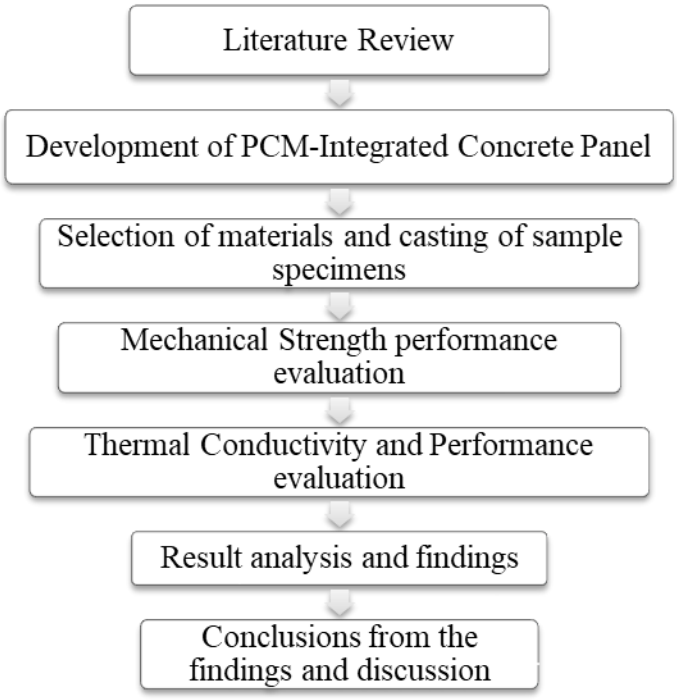
Literature Review
Development of PCM-Integrated Concrete Panel
Selection of materials and casting of sample specimens
Mechanical Strength performance evaluation
Thermal Conductivity and Performance evaluation
Result analysis and findings
Conclusions from the findings and discussion

***Figure 3**. Working Methodology Flow Chart*

5. EXPECTED OUTCOME OF THE RESEARCH

In the earlier approach, it was indicated that additional assessment was required on their direct incorporation with concrete or mortar in terms of strength performance, and the majority of the experimental studies, building interior envelope materials should be used for energy efficiency. The aim of this work is to create a concrete wall panel that incorporates phase change material (PCM) for the purpose of thermal energy storage sustainable construction materials.

1. The previous unfavorable outcomes identified from the literature survey can be minimized by making PCM-integrated concrete wall panels with adequate specifications and processes.
2. The mechanical strength properties of the PCM-integrated concrete wall panels will be able to identify by integrating a different range of PCM mix proportions.
3. It is going to be recognize the PCM-integrated concrete wall panels for thermal energy management compare to PCCWP in terms of the thermal comfort and constraints for building and also try to make the possibilities of sustainable building material.

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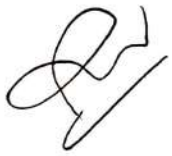

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SHORT SYNOPSIS

by

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ABSTRACT

Incorporating Phase Change Material (PCM) into buildings for thermal energy management, it is possible to significantly enhance energy efficiency. Thermal energy management approaches based on environmentally assisting construction materials is considered as one of feasible systems. PCMs have the privilege to save energy by latent heat and to take up less volume than other thermal storage construction materials. Phase Change Materials may be used into the building envelope through several methods. One of the most streamlined approaches of incorporating PCM is directly into the construction materials. This technique reduces the

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